A. G. Contract No. KR94 2566TRN
ECS File No.: JPA 94-169
Project: 87 MA 202 H2305 03D
Section: SR-87, Mesquite Wash
to Sycamore Creek

INTERAGENCY AGREEMENT
BETWEEN
THE ARIZONA DEPARTMENT OF TRANSPORTATION
AND
THE ARIZONA GEOLOGICAL SURVEY

THIS AGREEMENT is entered into 2 November, 1994, between the agencies of the STATE OF ARIZONA, to wit; the DEPARTMENT OF TRANSPORTATION, acting by and through it's HIGHWAYS DIVISION (the "ADOT") and the ARIZONA GEOLOGICAL SURVEY, acting by and through its DIRECTOR (the "AGS").

I. RECITALS

1. The ADOT is empowered by Arizona Revised Statutes Section 28-108 to enter into this agreement and has by resolution, a copy of which is attached hereto and made a part hereof, resolved to enter into this agreement and has delegated to the undersigned the authority to execute this agreement on behalf of the ADOT.

2. The AGS is empowered by Arizona Revised Statutes Section 27-152.01 to enter into this agreement and has resolved to enter into this agreement and has authorized the undersigned to execute this agreement on behalf of the AGS.

3. Incident to an improvement project to State Route 87 (SR-87) contemplated by the ADOT, it is necessary to assess the seismic hazard associated with the Sugarloaf fault which SR-87 traverses. The AGS has agreed to accomplish the assessment, at an estimated cost of $9,300.00, all at ADOT expense, hereinafter referred to as the Project, for the safety and benefit of the motoring public.

THEREFORE, in consideration of the mutual agreements expressed herein, it is agreed as follows:

II. SCOPE

1. The AGS will:

a. Accomplish the Project generally in accordance with Exhibit A, which is attached hereto and made a part hereof. Provide ADOT with appropriate progress reports, and a final report.

b. No more often than monthly, invoice the ADOT for the reasonable direct actual cost of the Project, in an amount estimated at $9,300.00.

2. The ADOT will:

a. Review the progress and draft final reports and provide comments.

b. Reimburse the AGS within 30 days after receipt and approval of invoices, in a total amount estimated at $9,300.00.

III. MISCELLANEOUS PROVISIONS

1. This agreement shall remain in force and effect until completion of said Project and reimbursements; provided, however, that this agreement may be cancelled at any time prior to the commencement of performance, upon thirty (30) days written notice to the other party.

2. This agreement shall become effective upon filing with the Secretary of State.

3. This agreement may be cancelled in accordance with Arizona Revised Statutes Section 38-511.

4. The provisions of Arizona Revised Statutes Section 35-214 are applicable to this contract.

5. In the event of any controversy which may arise out of this agreement, the parties hereto agree to abide by required arbitration as is set forth for public works contracts in Arizona Revised Statutes Section 12-1518.

6. All notices or demands upon any party to this agreement shall be in writing and shall be delivered in person or sent by mail addressed as follows:

Arizona Department of Transportation
Joint Project Administration
205 South 17 Avenue, Mail Drop 616E
Phoenix, AZ 85007

Arizona Geological Survey
State Geologist
845 North Park Avenue, Room 100
Tucson, AZ 85719

7. Attached hereto and incorporated herein is the written determination of legal counsel that the parties are authorized under the laws of this state to enter into this agreement and that the agreement is in proper form.

IN WITNESS WHEREOF, the parties have executed this agreement the day and year first above written.

STATE OF ARIZONA

GEOLOGICAL SURVEY

By Larry D. Fellows
LARRY D. FELLOWS, Ph.D.
Director

DEPARTMENT OF TRANSPORTATION

By Peter L. Eno
PETER L. ENO
Contract Administrator

429
11oct

JPA 94-169

RESOLUTION

BE IT RESOLVED on this 4th day of October 1994, that I, the undersigned LARRY S. BONINE, as Director of the Arizona Department of Transportation, have determined that it is in the best interests of the State of Arizona that the Department of Transportation, acting by and through the Highways Division, to enter into an agreement with the Arizona Geological Survey for the purpose of defining responsibilities for a Sugarloaf geological fault assessment on SR-87, Mesquite Wash to Sycamore Creek.

Therefore, authorization is hereby granted to draft said agreement which, upon completion, shall be submitted to the Contract Administrator for approval and execution.

Larry K Robinson

FOR: LARRY S. BONINE
Director

Detailed Paleoseismic Investigation of the Sugarloaf Fault Zone, Central Arizona

A Proposal to the

Arizona Department of Transportation

from the

Arizona Geological Survey

Philip A. Pearthree, Ph.D.

and

Larry D. Fellows, Ph.D., P.G.,

Principal Investigators

September 1994

Exhibit A

to

JPA 94-169

Introduction

The Sugarloaf fault zone crosses Arizona Highway 87 and may pose a hazard to highway bridges and other structures in the area. The Sugarloaf fault zone was identified as a Quaternary fault in a reconnaissance study conducted for the U.S. Bureau of Reclamation (Fugro, 1981). Subsequent studies concluded that the youngest rupture along the Sugarloaf fault probably occurred in the past 10,000 to 20,000 years, and that there have been recurrent ruptures on the fault during the Quaternary (the past 2 million years or so; Menges and Pearthree, 1983; 1989; Pearthree and others, 1983; Pearthree and Scarborough, 1984; Anderson and others, 1986). Very little is known about the frequency of ruptures on this fault, however, and this is a critical factor in evaluating the seismic hazard associated with it. We propose to conduct a detailed paleoseismic investigation of the Sugarloaf fault in order to evaluate the seismic hazard associated with the fault. The objectives of the research proposed here are to (1) evaluate the age of the youngest fault rupture; (2) gather and interpret evidence of recurrent Quaternary fault ruptures; (3) estimate the size of the earthquake generated by fault ruptures using displacement and rupture-length data; and (4) generate a probabilistic contour map of local seismic acceleration based on our assessment of the size and frequency of earthquakes generated by the Sugarloaf fault.

Seismotectonic Setting

The Sugarloaf fault is located in the Transition Zone between the Colorado Plateau of northern Arizona and the Basin and Range of southern and western Arizona. The Transition Zone has experienced low to moderate levels of seismic activity during the historical period. The largest historical earthquake in this region was a magnitude ~5 event located near Chino Valley, north of Prescott (DuBois and others, 1982). Late Quaternary faults (faults active in the past several hundred thousand years) in Arizona are concentrated in a band stretching from northwestern Arizona into central Arizona. The Transition Zone of central Arizona contains 5 recognized late Quaternary faults (Pearthree and others, 1983). Two of these faults have been studied in some detail. The Big Chino fault, located northwest of Prescott, is characterized by long ruptures (35 to 50 km),

sizable displacements per rupture (~2 m), and an average recurrence interval of 20,000 to 30,000 years between ruptures (Euge and others, 1992). The Horseshoe fault, located adjacent to Horseshoe Dam on the Verde River, is about 20 km long, has about 0.5 to 2 m of displacement per rupture, and has an recurrence interval of about 50,000 to 100,000 years between ruptures (Piety and Anderson, 1990). Given what is known about other faults in the Transition Zone, it is likely that the Sugarloaf fault is characterized by recurrence intervals between ruptures of tens of thousands of years.

Proposed Work

We propose to assess the seismic hazard associated with the Sugarloaf fault by conducting detailed paleoseismological investigations of the fault to estimate the size of paleoearthquakes and the frequency of their occurrence. Information obtained from these paleoseismological investigations will then be integrated into a probabilistic assessment of the potential seismic shaking in the area around the Sugarloaf fault. With this information, engineers at the ADOT will be able to evaluate the hazard posed to planned highway bridges along State Highway 87.

The proposed investigations are divided into several phases:

1) Background work. This will include review of previous geologic studies of the Sugarloaf fault, acquisition of large-scale aerial photographs for use in detailed mapping, and reconnaissance field investigations to review existing geologic mapping of the fault.

2) Detailed geologic mapping. The portion of the Sugarloaf fault suspected of recent activity will be mapped in detail in the field using large-scale aerial photographs. During the course of this mapping, we will delineate faulted and unfaulted alluvial surfaces, document natural fault exposures, collect topographic profiles of fault scarps, and choose specific sites for trench excavation.

3) Stratigraphic investigations. Two or more trenches will be excavated across the Sugarloaf fault and interpreted; any promising natural exposures of the fault zone will be described as well. Any datable organic material that bears on the age of fault rupture will be collected and submitted to a laboratory for analysis. In addition, we will describe soil profiles associated with faulted and unfaulted alluvial surfaces. The objectives of the

stratigraphic investigations will be to constrain estimates for the age of youngest fault rupture, estimate the frequency of fault ruptures during the Quaternary, and estimate the amount of displacement per fault rupture.

4) Summary of the paleoseismology of the Sugarloaf fault. We will integrate the results of all the field investigations outlined above in order to assess the behavior of the Sugarloaf fault. We will estimate the age and the magnitude of the youngest rupture along the fault. We will evaluate the age and magnitude (displacement and length) of previous ruptures as well as is feasible. We will estimate a long-term fault slip rate from our stratigraphic investigations.

5) Seismic shaking evaluation. Information obtained in the paleoseismological investigations will be used in a seismic hazard evaluation for the areas around the Sugarloaf fault. Estimates of slip per event and long-term slip rate will be used in a probabilistic evaluation of horizontal accelerations for the anticipated design life of the planned highway bridges. As a worse case scenario, we can also evaluate local accelerations that would result from rupture on the Sugarloaf fault.

6) Submission of reports. We will submit a draft report summarizing our investigations and conclusions to ADOT for review and comment. We will submit a final report after we receive ADOT comments.

Project Plan

1 October to 30 November 1994- Acquire aerial photographs of Sugarloaf fault area; conduct field investigations to evaluate/review evidence for Quaternary faulting along Sugarloaf fault; make very detailed surficial geologic map along portion of Sugarloaf fault suspected to have young rupture (from Sycamore Creek to ~0.5 km south of Highway 87); select sites for trench excavation across fault and have them evaluated for cultural or biological resources.

1 December to 31 December 1994 - Excavate and interpret trenches across Sugarloaf fault to obtain evidence of recency of fault rupture, frequency of fault rupture, and amount of displacement per fault rupture; clean off and describe any other promising natural exposures of faulted alluvium along the fault; if organic material is found that bears on the age of youngest fault rupture, collect it and submit to laboratory for analysis.

1 January to 31 January 1995 - Incorporate fault slip rate, fault length, and displacement per rupture event into probabilistic assessment of seismic shaking hazard in this area; submit draft report to ADOT.

1 February to 28 February 1995- ADOT review of draft report; AZGS revisions of draft report and submission of final report to ADOT.

References

Anderson, L.W., Piety, L.A., and Hansen, R.A , 1986, Seismotectonic investigation, Stewart Mountain Dam, Salt River Project, Arizona: U.S. Bureau of Reclamation Seismotectonic Report 86-2, 41 p. plus appendices.

DuBois, S.M., Smith, A.W., Nye, N.K., and Nowak, T.A., 1982, Arizona Earthquakes, 1776-1980: Arizona Bureau of Geology and Mineral Technology (ABGMT) Bulletin 193, 456 p., scale 1:1,000,000.

Euge, K.M., Schell, B.A., and Lam, I.P., 1992, Development of seismic acceleration contour maps for Arizona: Final Report to the Arizona Department of Transportation, 328 p. plus appendices.

Fugro, 1981, Seismotectonic study, Stewart Mountain Dam, Arizona: Reoprt prepared for Water and Power resources Service (U.S. Bureau of Reclamation), Denver, Colorado, 39 p.

Menges, C.M., and Pearthree, P.A., 1983, Map of Neotectonic (Latest Pliocene-Quaternary) Deformation in Arizona: Ariz. Bur. Geol. Min. Tech. OFR 83-22, 48 p., 1:500,000 scale.

Menges, C.M., and Pearthree, P.A., 1989, Late Cenozoic tectonism and landscape evolution in Arizona, in Jenney, J., and Reynolds, S.J., eds., Geologic Evolution of Arizona: Arizona Geological Society Digest 17, p. 649-680.

Pearthree, P.A., Menges, C.M., and Mayer, Larry, 1983, Distribution, recurrence, and possible tectonic implications of late Quaternary faulting in Arizona: ABGMT OFR 83-20, 51 p.

Pearthree, P.A., and Scarborough, R.B., 1984, Reconnaissance analysis of possible Quaternary faulting in central Arizona: ABGMT OFR 85-4, 75 p. map scale 1:250,000.

Piety, L.A., and Anderson, L.W., 1990, Seismotectonic investigation for Horsheshoe and Bartlett dams - Salt River Project, Arizona: U.S. Bureau of Reclamation Seismotectonic Report 90-7, 59 p. plus appendices.

Principal Investigator and Institutional Qualifications

Geologists working for the Arizona Geological Survey have conducted extensive research into earthquake hazards in Arizona during the past 20 years. Larry D. Fellows, Ph.D., P.G., has overseen these efforts in his position of State Geologist and Director of the AZGS. Philip A. Pearthree, Ph.D., has been involved in many paleoseismologic investigations in Arizona during the past 15 years. Selected seismic-hazard publications, maps, and reports released by the AZGS and other publications by P.A. Pearthree are listed below.

Selected Publications and Reports

Bull, W.B., and Pearthree, P.A., 1988, Frequency and size of Quaternary surface ruptures on the Pitaycachi fault, northeastern Sonora, Mexico: Bull. Seis. Soc. Amer., v. 78, p. 956-978.

Demsey, K.A., and Pearthree, 1990, Late Quaternary surface-rupture history of the Sand Tank fault and associated seismic hazard for the proposed superconducting super collider site, Maricopa County, Arizona: AZGS OFR 90-1, 43 p.

Demsey, K.A., and Pearthree, P.A., 1994, Surficial and environmental geology of the Sierra Vista area, Cochise County, Arizona: AZGS OFR 94-6, 14 p., scale 1:24,000.

DuBois, S.M., and Smith, A.W., 1980, The 1887 earthquake in San Bernardino Valley, Sonora: Historic accounts and intensity patterns in Arizona: ABGMT Special Paper 3, 112 p.

DuBois, S.M., Smith, A.W., Nye, N.K., and Nowak, T.A., 1982, Arizona Earthquakes, 1776-1980: Arizona Bureau of Geology and Mineral Technology (ABGMT) Bulletin 193, 456 p., scale 1:1,000,000.

Jackson, G.W., 1990, Tectonic geomorphology of the Toroweap fault, western Grand Canyon, Arizona: Implications for transgression of faulting on the Colorado Plateau: AZGS OFR 90-4, 67 p., scale 1:24,000.

Machette, M.N., Personius, S.V., Menges, C.M., and Pearthree, P.A., 1986, Map showing Quaternary and Pliocene faults in the Silver City 1 X 2 degree Quadrangle and the Douglas 1° x 2° Quadrangle, southeastern Arizona and southwestern New Mexico: U.S. Geol. Surv. Map MF-1465-C, 1:250,000 scale, 20 p.

Menges, C.M., and Pearthree, P.A., 1983, Map of Neotectonic (Latest Pliocene-Quaternary) Deformation in Arizona: Ariz. Bur. Geol. Min. Tech. OFR 83-22, 48 p., 1:500,000 scale.

Menges, C.M., and Pearthree, P.A., 1989, Late Cenozoic tectonism and landscape evolution in Arizona, in Jenney, J., and Reynolds, S.J., eds., Geologic Evolution of Arizona: Arizona Geological Society Digest 17, p. 649-680.

Pearthree, P.A., 1986, Late Quaternary faulting and seismic hazard in southeastern Arizona and adjacent portions of New Mexico and Sonora, Mexico: ABGMT OFR 86-8, 22 p.

Pearthree, P.A., 1990, Geomorphic Analyses of Young Faulting and Fault Behavior in Central Nevada: Ph.D. Dissertation (unpublished), University of Arizona, Tucson, 212 p.

Pearthree, P.A., and Calvo, S.S., 1987, The Santa Rita fault zone: Evidence for large magnitude earthquakes with very long recurrence intervals, Basin and Range province of southeastern Arizona: Bull. Seis. Soc. Amer., v. 77, p. 97-116.

Pearthree, P.A., Bull, W.B., and Wallace, T.C., 1990, Geomorphology and Quaternary geology of the Pitaycachi fault, northeastern Sonora, Mexico, in Gehrels, G.E., and Spencer, J.E., eds., Geologic Excursions Through the Sonoran Desert Region, Arizona and Sonora: AZGS Special Paper 7, p 124-135.

Pearthree, P.A., McKittrick, M.A., Jackson, G.W., and Demsey, K.A., 1988, Geologic map of Quaternary and Upper Tertiary deposits of the Tucson 1°x 2° Quadrangle, Arizona: AZGS OFR 88-21, 1:250,000 scale.

Pearthree, P.A., Menges, C.M., and Mayer, Larry, 1983, Distribution, recurrence, and possible tectonic implications of late Quaternary faulting in Arizona: ABGMT OFR 83-20, 51 p.

Pearthree, P.A., and Scarborough, R.B., 1984, Reconnaissance analysis of possible Quaternary faulting in central Arizona: ABGMT OFR 85-4, 75 p. map scale 1:250,000.

Scarborough, R.B., and Pearthree, P.A., 1986, Reconnaissance assessment of Quaternary faulting in the Gila River region from San Carlos Reservoir to Coolidge, Arizona: ABGMT OFR 88-15, 12 p. map scale 1:250,000

Scarborough, R.B., Menges, C.M., and Pearthree, P.A., 1983, Map of Basin and Range (Post-15 m.y.a.) Exposed Faults, Grabens, and Basalt-Dominated Volcanism in Arizona: Ariz Bur. Geol. Min. Tech. OFR 83-21, 25 p., 1:500,000 scale.

Scarborough, R.B., Menges, C.M., and Pearthree, P.A., 1986, Map of late Pliocene-Quaternary (post 4 m.y.) faults, folds, and volcanic outcrops in Arizona: Arizona Bureau of Geology and Mineral Technology Map 22, 1:1,000,000 scale.

Proposed Budget

Total Project Cost				**$9,284**
Salary and Benefits				**$6,304**
	weeks	rate/hr		
Research Geologist	4	$19.50		$3,120
Benefits (full)	23%			$709
Geologist II	5	$11.15		$2,230
Benefits (limited)	11%			$245
Operations				**$1,050**
aerial photos and topographic base maps				$200
field supplies				$100
*radiocarbon dating-$500/date AMS, $250/date conventional				$750
Travel				**$1,930**
	days	$/day		
vehicle costs	20	$20.00		$400
	$/gal	miles/gal	miles	
gas	1.2	12	1500	$150
	nights	$/night		
lodging	15	$40.00		$600
	person-days	$/day		
per diem	30	$26.00		$780

* Applicable only if datable material is found during investigations and dates can be obtained within the project schedule.